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Microscopic studies of geometry in the fractional quantum Hall effect

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Recently, there has been renewed interest in the fractional quantum Hall effect due to emerging connections between topological order, geometry and broken symmetry. Incompressible fluids, like Laughlin states, have been shown to have intrinsic degrees of freedom that can be viewed as ”quantum geometry”. These degrees of freedom play an important role in the low-energy physics of incompressible fluids, but they are also tied to the breaking of rotational invariance, which allows for the co-existence of topological order and broken symmetry in the form of ”nematic” quantum Hall states. In this talk, I will present an overview of the microscopic studies of geometry in the fractional quantum Hall effect focusing on its physical probes, such as the band mass anisotropy and tilted magnetic field. I will also introduce a generalization of the Haldane pseudopotentials to the case where rotational symmetry is explicitly broken. This approach not only facilitates the numerical description of anisotropic quantum Hall systems, but also reveals new types of bound molecular states. Some applications of generalized Haldane pseudopotentials will be discussed, including systems with tilted magnetic field, the nematic quantum Hall effect, and fractional Chern insulators where the anisotropy is intrinsically present due to the underlying lattice structure.